PATENT SPECIFICATION

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COMPLETE SPECIFICATION

Improvements in or relating to Fire Hose

We, F. REDDAWAY & Co., LIMITED, a British Company, of Cheltenham Street, Pendleton, Manchester, 6, in the County of Lancaster, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

Rubber-lined fire hose has been made for many years and has obvious advantages over unlined hose, but it also has the disadvantage that the rubber lining adds considerably to the weight and reduces the flexibility of the hose. The application of the lining to the hose is effected by drawing it into the woven jacket of the hose, expanding it therein by steam pressure and using an adhesive to secure it to the jacket. The rubber is partly vulcanised before being drawn into the jacket in order to give it the necessary mechanical strength for such operation, and it has been well established in the industry, from practical experience, that the rubber cannot be less than about .03 inches thick, to enable it to be fitted to the hose in this manner, as otherwise it does not have sufficient strength to enable it to be drawn into a commercial length of hose, which is normally 50 feet or more. Also, any projection in the weave of the jacket, such as a knot, causes the rubber to flow, when expanded as aforesaid and a flow or weak area in the lining is found to result unless the rubber lining is at least about .04 inch thick.

In order to enable the thickness of the lining to be reduced, it has been proposed in Specification No. 538,455 to apply a thin film of rubber or other sealing agent, such as a synthetic plastic composition, to a light woven carrier, which is formed into a tube and drawn into the jacket of the hose. This method makes it possible to provide a rubber or other lining which is thinner than had hitherto been possible and therefore facilitates the production of lighter hose, but it involves additional operations with the attendant expense.

The present invention is based upon an appreciation of the following properties possessed by certain gelled plasticised polyvinyl chloride (P.V.C.) compositions, namely:—

(a) that they can be fabricated, e.g. by extrusion, into a tube of rubber-like nature and having sufficient tensile strength to enable it to be drawn without damage into a standard length of fire hose, sufficient resistance to flow, when cold, to provide an effective thin, flexible lining for the jacket of the hose and yet sufficient flow, when suitably heated, to permit it to flow without splitting around knots in the weave of the jacket to provide a lining of uniform thickness throughout; and

(b) that such a gelled extruded tube may be made of considerably smaller diameter than the intended finished diameter but with a greater wall thickness than the intended finished wall thickness, and subsequently expanded by internal application of fluid under pressure, to form a thin lining for the jacket of the hose.

The polyvinyl chloride compositions contemplated by the invention contain not less than 35% and not more than 65% by weight of polyvinyl chloride of high molecular weight, and a suitable plasticizing agent and contain not more than 10% by weight of other matter. They have substantial flexibility and viscosity, tensile strength and elongation as follows:—

(a) Viscosity—a minimum Mooney viscometer reading of 60 at 100° C. and minimum Williams plastometer reading of 700 at 100° C. over a three minute cycle using a 5 kg. weight.

(b) Ultimate tensile strength, determined in accordance with B.S. 903/1950, minimum of 1000 lbs. per sq. inch at 20° C.

(c) Elongation, determined in accordance with B.S. 903/1950, minimum at break of 350% at 20° C.

A polyvinyl chloride composition of this character is referred to herein as a polyvinyl chloride composition of the character hereinbefore recited. For convenience the abbreviation P.V.C. for polyvinyl chloride has been used in parts of this specification.

The invention provides a method of pro-

ducing fire hoses having a thin impervious lining of polyvinyl chloride, which comprises introducing into the jacket of the hose a tube of a gelled polyvinyl chloride composition of the character hereinbefore recited, said tube having an external diameter considerably less than the internal diameter of the jacket and a wall thickness substantially exceeding the thickness of the intended lining, and thereafter admitting fluid under pressure to the interior of the tube to expand it into contact with the jacket and heating the tube to bond it to the jacket.

The tube may be caused to expand into contact with and to bond to the jacket by admission of hot fluid under pressure to the interior of the hose. As noted later, however, we prefer to expand the tube into contact with the jacket by admitting cold fluid under pressure to the interior of the tube and then to effect adhesion of the tube to the jacket by replacing the cold fluid, without releasing the pressure, by hot fluid. It is not necessary in all cases to use an adhesive for bonding the P.V.C. tube to the jacket, but the use of an adhesive for the purpose is preferred. The adhesive is conveniently applied to the interior of the jacket prior to introduction of the P.V.C. tube into the jacket.

The degree of expansion of the P.V.C. tube contemplated by the invention is substantial and is of a different order from the small degree of expansion experienced by the conventional rubber lining, since in the latter case a small clearance only is provided between the rubber lining tube and the jacket. In carrying out the method according to the invention, the increase in bore of the P.V.C. tube as the result of expansion thereof will normally be from 20% to 40% of the bore of the jacket. Thus the P.V.C. tube may conveniently have an outside diameter of the order of 60% of the bore of the jacket and a wall thickness such that the thickness of the tube, after expansion, is from .005—.025 inch and preferably about .015 inch.

To a first approximation, the thickness of the lining, t_2, is related to the wall thickness, t_1, of the tube, by the formula $t_2 = t_1 \times \frac{\text{tube bore}}{\text{hose bore}}$.

Thus the following is a typical example of appropriate sizes of tube for introduction into hoses of different bore to produce a lining 0.012 inch in thickness:—

Hose bore	Tube wall thickness t_1	Tube bore	Lining thickness t_2
1″	0.020″	0.6″	0.012″
2″	„	1.2″	„
3″	„	1.8″	„
4″	„	2.4″	„

The method according to the invention possesses the following advantages over those at present in use for the manufacture of rubber-lined hose:—

(a) It is possible to manufacture without difficulty by extrusion a P.V.C. tube of thickness as small as .02—.03 inch or less.

(b) Such a thin P.V.C. tube can, unlike an unvulcanised rubber tube of corresponding thickness, be drawn without damage into a 50 ft. length of hose, and can thereafter be expanded in the jacket of the hose to produce a P.V.C. lining of thickness .005—.025 inch.

(c) The P.V.C. tube requires exposure to heat for a considerably less time, at the conveniently low temperature of processing, to bond it to the jacket, than is the case with a rubber lining which must be vulcanised *in situ* in the jacket, and the P.V.C. tube also conforms to the knots in the weave when expanded into contact with the jacket without any tendency to split adjacent to the knots.

(d) The P.V.C. lining is flame resistant and, within limits, impervious to acids, alkalis, oils and other influences which are destructive to rubber.

The P.V.C. composition utilized is free, or substantially free, from fillers though it may contain not more than 10% by weight of other matter, as aforesaid. Various plasticizers can be employed, and in one particular example the tube is extruded from a mix consisting of 100 parts by weight of the P.V.C. polymer known as "Geon" 101, 80 parts by weight of tricresyl phosphate, 20 parts by weight of dioctyl sebacate, 6 parts by weight of dibasic lead phosphite, 1.5 parts by weight of calcium stearate and 1—2 parts by weight of the dianisidene red pigment supplied commercially by the Geigy Co. Ltd. under the designation "Red DRS". "Geon" is a Registered Trade Mark. Gelling is effected by heating to a temperature of at least 140 C., and preferably 160—170° C., either prior to or during extrusion of the tube.

We find that, where the jacket tends to expand radially under the expansion pressure, as is the case when the weft is of nylon, the lining tube of P.V.C. when expanded into contact with the jacket tends to split longitudinally, whereas if the weave is such that the jacket tends to expand longitudinally, the P.V.C. tube tends to develop radial splits. Any tendency of the lining tube to split can, however, be obviated by subjecting the tube, when introduced into the jacket, first to internal pressure by cold fluid, e.g. air at room temperature and about 45 lbs./sq. in., and thereafter gradually and without releasing the internal pressure introducing hot fluid, e.g. steam or hot air, into the tube, at a temperature of about 105—120° C.

In one particular example an extruded tube of 1.5 inches outside diameter and wall thickness .025 inch and of the above-mentioned P.V.C. composition was drawn into a hose of 2.5 inches bore, which had previously been

treated internally with a suitable P.V.C.-to-fabric adhesive, such as Welvic cement grade B 2010. Welvic is a Registered Trade Mark.

The adhesive was applied to the hose as follows:—

A sufficient quantity of the adhesive was first introduced into one end of the jacket of the hose. This end of the jacket was then introduced into the nip of a pair of power driven light rollers.

This process serves:—

1. To restrict the amount of adhesive remaining on the wall of the jacket;

2. To ensure that the whole inner surface of the jacket is impregnated with adhesive;

3. To provide a driving medium of constant speed.

After the jacket has left the rollers and before the adhesive had time to set, low pressure air was introduced into the hose to prevent contact and consequent adhesion between the inner surfaces.

The jacket was then allowed to stand for a time sufficient to allow complete drying of the adhesive.

The extruded P.V.C. tube was next drawn into the jacket in the following manner. A wooden plug attached to one end of a cord was introduced into the hose jacket, and forced along it by means of a roller or rollers. When the plug emerged from the jacket the other end of the cord was tied to the end of the P.V.C. tube which was then drawn through.

After the extruded P.V.C. tube had been drawn into the jacket, air at room temperature and at a pressure of 45 pounds per square inch was introduced into the hose. After the jacket and tubular lining had been fully strained the cold air was replaced, without release of internal pressure in the hose, by hot air at a temperature of 108° C. to 110° C. and at a pressure which at no time was allowed to exceed 45 pounds per square inch. It was in fact found desirable gradually to reduce the pressure during this operation. Heating was over a period of twenty minutes after which time the hot air was released and cooling followed, maintaining sufficient pressure in the hose to prevent collapse of the tube while the lining regained its physical strength.

The following are examples of other P.V.C. compositions from which the lining tube may be fabricated:—

A

	Parts by Weight
"Geon" 101	100
Tricresyl phosphate	60
Dioctyl phthalate	30
Basic lead carbonate	3

B

	Parts by Weight
"Geon" 101	100
Tricresyl phosphate	60
Dioctyl phthalate	20
Dioctyl sebacate	15
Barium stearate	1
Basic lead carbonate	3

C

	Parts by Weight
"Geon" 101	100
Hycar 02.25	100
Sulphur	2
Zinc oxide	4
Stearic acid	1
Tetramethyl thiuram disulphide	1.5
Dioctyl phthalate	30
Tricresyl phosphate	30
Basic lead carbonate	3

(Hycar is a Registered Trade Mark)

D

	Parts by Weight
"Geon" 101	100
Trixylenyl phosphate	25
Dioctyl sebacate	30
Pigment ("Red DRS")	1
Basic lead carbonate	3

What we claim is:—

1. A method of producing fire hose having a thin impervious lining of polyvinyl chloride, which comprises introducing into the jacket of the hose a tube of gelled polyvinyl chloride composition of the character hereinbefore recited, said tube having an external diameter considerably less than the internal diameter of the jacket and a wall thickness substantially exceeding the thickness of the intended lining, and thereafter admitting fluid under pressure to the interior of the tube to expand it into contact with the jacket and heating the tube to bond it to the jacket.

2. A method according to Claim 1, wherein the increase in bore of the tube as the result of expansion thereof is from 20% to 40% of the bore of the jacket.

3. A method according to Claim 1, wherein the tube, when introduced into the jacket, has an outside diameter of the order of 60% of the bore of the jacket and a wall thickness such that the thickness of the tube, after expansion, is from .005—.025 inch.

4. A method according to Claim 3, wherein the tube is expanded to form a lining of thickness about .015 inch.

5. A method of producing fire hose having a thin impervious lining of polyvinyl chloride, which comprises introducing into the jacket of the hose a tube of gelled polyvinyl chloride

composition of the character hereinbefore recited, said tube having an external diameter considerably less than the internal diameter of the jacket and a wall thickness substantially exceeding the thickness of the intended lining, then admitting cold fluid under pressure to the interior of the tube to expand the tube into contact with the jacket and then, without releasing the internal pressure, admitting hot fluid to the interior of the tube to cause the tube to bond to the jacket.

6. A method according to Claim 5, wherein, to cause expansion of the tube and bonding thereof to the jacket, cold air at a pressure of about 45 lbs./sq. in. is first introduced into the tube and steam or hot air at a temperature of about 105—120° C. is afterwards gradually introduced into the tube.

7. A method according to any of the preceding claims, in which the tube is caused to bond to the jacket by means of a layer of adhesive interposed between the tube and the jacket.

8. A method according to any of the preceding claims, wherein the polyvinyl chloride tube is an extruded tube.

9. A method according to any preceding claim in which fluid pressure is maintained in the tube after it has bonded to the jacket and while it is allowed to cool.

10. A method of producing a fire hose having a thin lining of polyvinyl chloride substantially as described herein with reference to the foregoing example.

11. A fire hose having a thin impervious lining of polyvinyl chloride when manufactured by the method claimed in any preceding claim.

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PROVISIONAL SPECIFICATION

Improvements in or relating to Fire Hose

We, F. REDDAWAY & Co., LIMITED, a British Company, of Cheltenham Street, Pendleton, Manchester, 6, in the County of Lancaster, do hereby declare this invention to be described in the following statement:—

This invention relates to lined hose and is particularly, though not exclusively, applicable to fire hose, that is to say hose used for coupling to fire hydrants.

Rubber-lined fire hose has been made for many years and has obvious advantages over the original unlined hose, but it also has the disadvantage that the rubber lining adds considerably to the weight and reduces the flexibility of the hose. The application of the lining to the hose is effected by drawing it into the canvas hose, expanding it therein by steam pressure and using an adhesive to secure it to the canvas. The rubber is partly or wholly vulcanised before being drawn into the hose in order to give it the necessary mechanical strength for such operation, and it has been well established in the industry, from practical experience, that the rubber cannot be less than about $^1/_{32}$ inch thick, to enable it to be fitted to the hose in this manner, as otherwise it does not have sufficient strength for manipulation. Also, any projection to the weave, such as a knot, causes the rubber to flow, and a flaw or weak area in the lining is found to result unless the rubber lining is at least about $^1/_{32}$ inch thick.

In order to enable the thickness of the lining to be reduced, it has been proposed in U.K. Patent Specification No. 538,455 to use a light woven carrier, to which is applied a thin film of rubber or other material, the reinforced film thus produced being applied as a lining to the canvas hose in known manner. Such method makes it possible to provide a lining which is thinner than had hitherto been possible and therefore facilitates the production of lighter hose, but it involves additional operations with the attendant expense.

The present invention is based upon an appreciation of a property possessed by the ethenoids, e.g. polyvinyl chloride or copolymers (hereinafter referred to as P.V.C.), namely that it can be prepared as a gelled plasticised film much thinner than rubber, either as a fabricated tube or an extruded tube, yet, having the required tensile strength and sufficient resistance to flow to provide an effective yet thin lining and yet sufficient flow to provide a lining of equal thickness throughout, irrespective of knots and the like.

At the same time such a lining has all the advantages of the ethenoid compared with rubber such as, flame resistance, resistance to heat, acids, alkalis, oils, etc.

The present invention is also based upon an appreciation of a further property possessed by ethenoids such as P.V.C. in as much as it is possible for the tube to be made a smaller diameter than the intended finished diameter but with a greater wall thickness than the intended finished wall thickness.

By virtue of the above, extrusion of the tube and also the fabrication of a tube from sheet, is greatly facilitated.

A further advantage is the fact that the tube possesses much greater mechanical strength, which helps handling, manipulation and insertion into the canvas hose.

Such a tube after insertion in the canvas hose would be expanded to conform to the

contour of the canvas hose, as described in more detail hereafter, and thus the invention makes it possible to line a canvas hose with a much thinner impervious lining than has hitherto been possible.

It is claimed that by this method, lining of the order of 10 to 15 thousandths of an inch thick can be successfully applied.

The invention comprises the method of applying an impervious lining to a canvas hose wherein a gelled tubular film of an ethenoid such as P.V.C. and plasticiser is prepared of suitable dimensions to have the required tensile strength for manipulation including drawing into the hose and expanding and securing such film to the inner wall of the hose by means of fluid pressure and heat with or without the use of an adhesive.

The invention also comprises hose made by the method aforesaid.

In one example of the invention the first step is the manufacture of a tube from calendered sheet or by extrusion and as such a step is already established practice a description of same is not necessary for the purposes of this specification.

A sufficient quantity of suitable adhesive is first introduced into one end of the canvas hose.

This end of the canvas hose is then introduced into the nip of a light pair of mangling rollers which are power driven.

This process serves:—

1. To restrict the amount of adhesive remaining on the wall of the canvas hose;

2. To ensure that the whole inner surface of the canvas hose is impregnated with adhesive;

3. To act as a driving medium of constant speed.

After the canvas hose leaves the mangling rollers and before the adhesive has had time to set, low pressure air is introduced into the hose to prevent contact and consequent adhesion between the inner surfaces.

The canvas hole is then allowed to stand for a time, sufficient to allow complete drying of the adhesive.

A tubular lining of an ethenoid in a suitably plastic condition and of the appropriate smallness in diameter and thickness of wall is then drawn through the canvas hose by means of the conventional carrier. For instance, for a fine hose having a finished bore of 2.5 inches diameter, the tubular plastic lining may be 1.5 inches diameter with a wall thickness of 0.025 inches.

The hose is then fitted to nozzles at each end and steam pressure applied to the interior which expands the ethenoid lining into intimate contact with the canvas hose with consequent adhesion thereto over the whole area. The lining obtained from a tube of the dimensions above given will, when expanded, have a wall thickness of 0.015 inches.

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